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Design LTE Microstrip Antenna Rectangular Patch with Beetle-Shaped Slot

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Abstract

In this paper, the microstrip antenna rectangular patch with beetle shaped slot is presented. The characterization results of the proposed antenna obtained by changing the dimensions of the ground plane. CST software is used to design and analyze this proposed antenna. The simulated results of proposed antenna show that the antenna works at the frequency of 2.1 GHz while the return loss of -32.18 dB with the bandwidth reaches 155.19 MHz and the gain of 3.895 dBi.

Keywords: *Patch Antenna, LTE, Beetle-Shaped Slot*

1. Introduction

LTE (Long Term Evolution) technology has been released. LTE will be the step towards the fourth generation (4G) originated from radio technology which is designed to improve network capacity and speed. LTE provides downlink capacity of at least 100 Mbps and uplinks capacity of at least 50 Mbps [1].

Microstrip antenna is suitable for LTE application. Nowadays, it is increasingly used for wireless application because of its low cost and easy to fabricate. However, the microstrip antenna has a weakness in bandwidth. It has small bandwidth. To overcome it, there are several ways to broaden the bandwidth such as creating a slot, thicken the substrate, array the elements of antenna, ground plane modification, etc. Papers [2-5] has discussed the affect of changing the shape of ground plane dimension to the frequency and bandwidth of microstrip antennas. They show that the bandwidth increased by changing the shape of ground plane. Papers [6-7] has proposed the microstrip antenna used for applications such as WLAN, UMTS, LTE and WIMAX. Rationing coaxial probe is used to optimize the antenna impedance which is connected to the patch and the outer conductor connected to the ground plane [8-13]. In this paper, the rectangular microstrip patch antenna with beetle-shaped slot uses the coaxial probe for LTE applications with operating frequency of 2.1 GHz. Paper [14] discusses the optimal synthesis of fixed-geometry linear array antennas for dynamically reconfigure their radiation pattern. CST software is used to design the proposed antenna. The simulated results show that the return loss of -32.18 dB and the gain of 3.895 dBi has been achieved. While the bandwidth reaches 155.19 MHz and the radiation pattern of proposed antenna is omni-directional.

2. Research Method

The proposed rectangular microstrip antenna is designed by using CST software with beetle-shaped slot on patch and coaxial probe feed. The FR-4 with dielectric constant (ε_r) of 4.4 and 1.6 mm of thickness is chosen.

There are several formulas that are used to determine the size of the rectangular-shaped microstrip antenna.

Equation (1) is used to specify the patch width (w), equation (2)-(3) are used to calculated the patch length:

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$$W = \frac{c}{2f_r\sqrt{\frac{(\varepsilon_r+1)}{2}}} \tag{1}$$

Description :
C = the speed of light (3x10^{8}m/s)
f_r = frequency
ε_r = the dielectric constant of the substrate

$$\varepsilon_{reff} = \frac{\varepsilon_r+0.3}{2} + \frac{\varepsilon_r-1}{2}\left(\frac{1}{\sqrt{1+12\left(\frac{h}{w}\right)}}\right) \tag{2}$$

Description :
h = height substrate
ε_{reff} = The effective dielectric constant

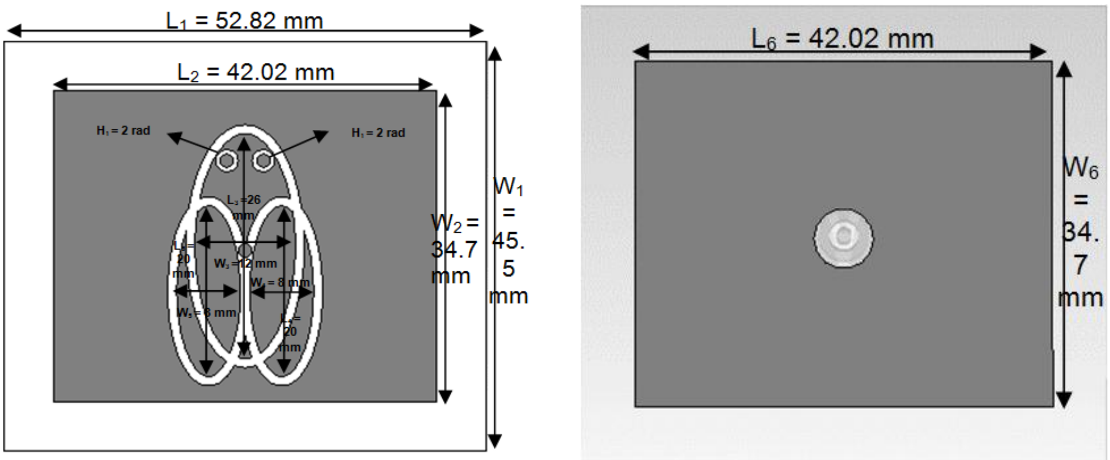
$$\Delta l = \frac{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff})\left(\frac{W}{h}+0.8\right)} \tag{3}$$

$$Leff = \frac{c}{4f_r\sqrt{\varepsilon_{reff}}} \tag{4}$$

Description :
Leff = the effective length

$$L = L_{eff} - 2\,\Delta L \tag{5}$$

From the calculations, the length and the width of patch are 34.7 mm and 42.02 mm, respectively with dimension of substrate is 52.82 x 45.5 mm. Figure 1 shows the geometry of rectangular patch microstrip antenna with the beetle-shaped slot. The rectangular ground with circular slot in the middle of the ground plane is designed. The dimension of ground plane is 42.02 mm x 34.7 mm.



(a) Front view (b) back view

Figure 1. Geometry of beetle-shaped slot rectangular patch microstrip antenna

Table 1. The dimensions of proposed antenna

Dimension	Size (mm)/(rad)
W_1	45.5
W_2	34.7
W_3	12
W_4	8
W_5	8
W_6	34.7
L_1	52.82
L_2	42.02
L_3	26
L_4	20
L_5	20
L_6	42.02
H_1	2
H_2	2

3. Results and Analysis

In this paper, the characterization has been performed in order to obtain the desired return loss, bandwidth and frequency. The proposed antenna is expected to work at 2.1 GHz.

Table 2. Varying the width of ground plane

Characterization	Dimension ground (mm)		Working Frequency	Return loss ≤ -10 (dB)	Bandwidth
	L	W	(GHz)		(MHz)
1	42,02	34.7	1.985	-4.868	~
2	27.5	24	2.607	-19.129	323.18
3	27.5	19.5	2.093	-21.827	114.62
4	**27.5**	**19**	**2.1**	**-32.18**	**155.19**

Table 2 lists the width characterization of the ground plane. The first characterization is an initial design which the return loss is still above -10 dB. The initial dimensions are obtained from the calculation. The second characterization has resulted the bandwidth of 323.18 MHz with the width of ground plane of 24 mm and the length of 27.5 mm. For the third characterization, the smallest bandwidth is obtained of 114.62 MHz. The fourth characterization, the desired frequency of 2.1 GHz is achieved with the return loss of -32.18 dB and bandwidth of 155.19 MHz. Figure 2 shows the return loss of all characterization performed for the ground plane.

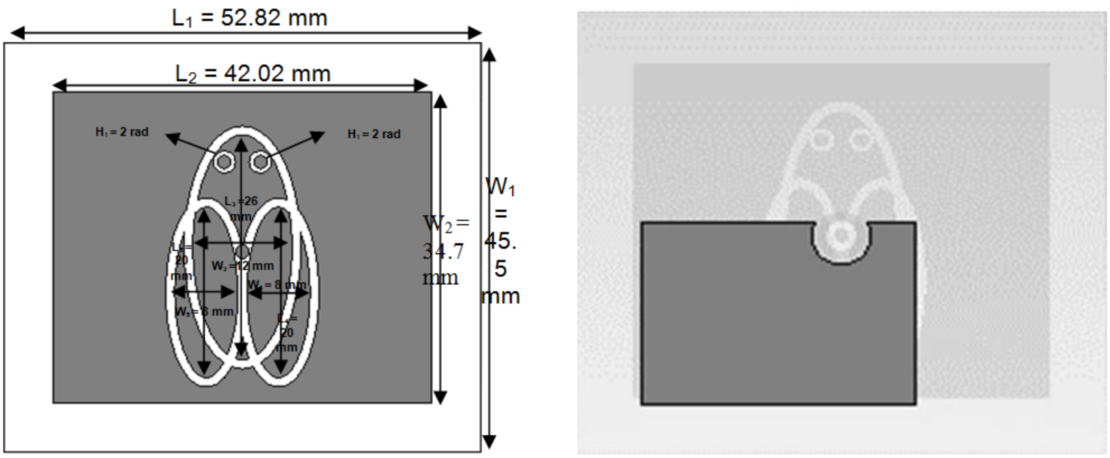


Figure 2. Final design of antenna dimension

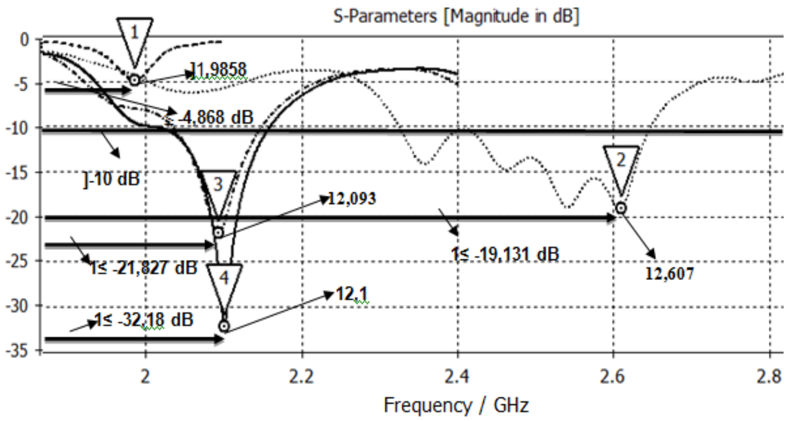
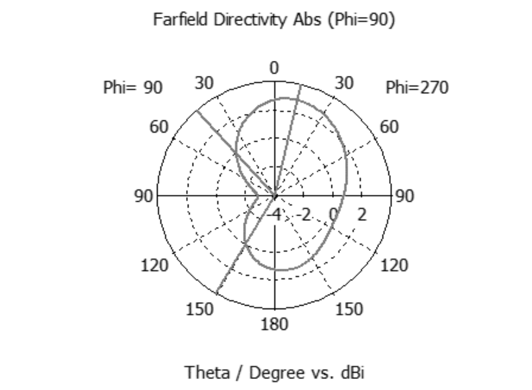
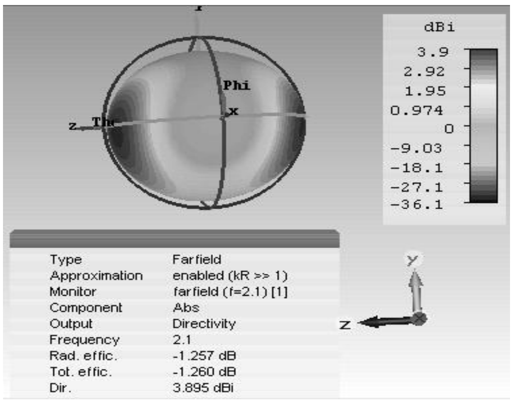


Figure 2. Frequency and return loss characterization.



(a)



(b)

Figure 3. Radiation Pattern Gain Simulation Result

Figure 3 shows the radiation pattern of the proposed antenna. The nearly omni directional is shown in Figure 3(a) and the simulated gain of the antenna is 3.895 dBi.

4. Conclusion

The simulation results of the fourth characterization show that the working frequency of 2.1 GHz was obtained when W_6 = 19 mm and L_6 = 27.5 mm. The bandwidth and the return loss of antenna are 155.19 MHz and -32.18 dB, respectively. The gain of antenna is 3.895 dBi with nearly omni directional radiation pattern.

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